Climate change related information – relevant for the TRB

icpdr iksd
International Commission for the Protection of the Danube River
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Annex 15 of the ITRBM Plan

1. Climate change relevant information in the TRB

Reasons for integrating climate change adaptation issues into river basin planning

The European Commission's White Paper "Adapting to climate change: Towards a European framework for action" (2009) calls for the promotion of "strategies which increase the resilience to climate change of health, property and the productive functions of land, inter alia by improving the management of water resources and ecosystems". It also sees a need for investigating the potential for policies and measures to boost ecosystem storage capacity for water, and for the development of guidance to ensure that River Basin Management Plans are climate proof in 2015.

In preparation for the DRBM Plan, an international conference on Climate Change in the Danube River Basin was held in Vienna in December 2007. The conclusions from the Conference, with relevance for the Tisza River basin too, mentioned that climate change impacts:

- Are an issue of Danube river basin-wide significance;
- Will be addressed by a step-wise approach;
- Will be addressed respecting all SWMIs for the DRB;
- Will address the issues of flood protection, low water discharges, drought and land use;
- Climate change signals for the DRB are sufficient to act beyond existing scientific uncertainties;
- Future infrastructure projects need to be climate proof:
- Holistic and coherent in their approach (linking all relevant sectors);
- Provide flexible management tools and no regret measures.

The middle of 19th century was marked by three important events. The first marked the end of the Little Ice Age, the second was the beginning of the pre-industrial era and the last the beginning of regular climatic records.

Based on the knowledge given by the regular climatic records specialists says that in the 20th century global temperatures rose by around 0.7^{0} C and is considered that 1998 was the warmest year since 1861 when records began. The Intergovernmental Panel on Climate Change (IPCC) concluded in one of its recent assessment report that most of the observed warming over the last 50 years can be attributable to human activities.

Recent observations confirm that the global mean temperature has increased by 0.8 °C compared with pre-industrial era for land and oceans, and by 1.0 °C for land alone.

Europe has warmed more than the global average (1.0 and 1.2 °C, respectively) and the realized climate projections suggest that the temperature will increase in Europe between 1.0–5.5 °C by the end of the 21 century, which is higher than projected global warming (1.8–4.0 °C).

From this point of view one of the most important problem of the 21 century is without any doubt the problem of climate change a problem that is now a "big" reality.

Climate change refers to a significant variation in the average climate that persists over a long period of time. Of course, some climate change can be the result of natural processes, but in its new sense climate change refers to changes in global climate that have arisen or who are predicted to arise in the future because of human activity that has changed or is expected to change the gaseous composition of the Earth's atmosphere.

From the sustainable development point of view it is generally agreed that the worst impacts of climate change will be supported by the developing world but in the same time is equally evident that the developed nations are not immune.

2. The Intergovernmental Panel on Climate Change (IPCC)

The Intergovernmental Panel on Climate Change (IPCC), in its 4th Assessment Report, in 2007, reconfirmed earlier scientific findings about the principals' aspects of climate change.

Climate change and the associated impacts require immediate action in order to safeguard both the economy and the environment of the world. At the 2007 UN Framework Convention on Climate Change (UNFCCC) Bali conference, the urgency of responding effectively to climate change through both adaptation and mitigation activities was recognized by a larger number of countries than ever before.

It is at this conference that EU has proposed a target of a maximum global temperature increase of 2 °C comparing with the pre-industrial level and a number of EU mitigation targets and actions by 2020. The proposed goal of EU can be achieved only based of an international climate policy regarding global greenhouse gas emission reductions.

3. EU climate change adaptation policy

The EU and its Member States have implemented strategies to achieve the objectives for reducing greenhouse gases under the Kyoto Protocol. But, even if these commitments will be fully implemented, it is recognized that significant changes in climate conditions will occur with severe impacts on Europe's water resources and water systems.

In fact the scientific evidence clearly suggests that climate change will result in more frequent and severe extreme events as floods and droughts, and that it will have long term effects not only on the availability of water in different regions in Europe but in the same time on the quality of water and water related ecosystems. So, water management needs to take into account these effects and news long term strategies concerning integrated water management must take into account the needs of water dependent economic sectors which will be more vulnerable and will need special options for adaptation.

For a couple of years, the EU's climate policy has specially been focused on measures to reduce greenhouse gas emissions and convincing international partners to sign the Kyoto Protocol. But, because of the increasingly frequency of extreme weather phenomena (such as heat waves and floods) EU gives more and more attention to the special need to define strategies and measures to adapt to the effects of global warming that in fact are already occurring.

That is way on 29 June 2007, the European Commission adopted a Green Paper *Adapting to climate change in Europe – options for EU action*, paper who proposes several options for action in order to reduce the effects of climate change.

The Green Paper looks at the impacts of climate change effects in European regions and attempts to define possible actions for adaptation at European level, recognizing in the same time that cooperation with member states and regions is essential.

In this Green Paper the European Commission defines his four priority options:

- early action to develop adaptation strategies in areas where current knowledge is sufficient;
- integrating global adaptation needs into the EU's external relations policy and building a new alliance with partners around the world;
- filling knowledge gaps on adaptation through EU-level research and exchange of information;
- setting up a European advisory group on adaptation to climate change to analyze coordinated strategies and actions.

The costs of the adaptation are expected to vary from inexpensive measures, such as awareness-raising and using drought-resistant crops, to expensive measures, such as building new dykes and power stations *because of failing hydropower stations.*

At European level adaptation is now included in the formulation of political objectives and has been incorporated into the updated European Climate Change Programme (ECCPII).

The European Commission has announced that a White Paper with more specific proposals for initiatives at EU level will be submitted in mid-2009.

4. Water quantity, river floods and droughts

Climate change, including changes in temperature, precipitation and snow cover, is intensifying the hydrological cycle. In the same time, other factors such as land-use changes, water management practices and extensive water withdrawals have considerably changed the natural flows of water, making it difficult to detect climate change-induced trends in hydrological variables.

In last decades Europe has been affected by several major droughts (e.g. the catastrophic drought associated with the summer 2003 heat wave in central parts of the continent). The regions most prone to an increase in drought hazard are southern and south-eastern Europe, but minimum river flows will also decrease significantly in many other parts of the continent, especially in summer.

In the same time, in the recent past, the recorded number of river floods has been strongly influenced by improved monitoring and reporting systems (e.g. 259 major river floods have been reported in Europe since 1990, of which 165 have been reported in the last eight years). For the next decades, floods are projected to occur more frequently in many regions, especially in winter and spring, but the estimates of changes in flood frequency and magnitude remain uncertain.

Projected climate induced changes in the hydrological cycle will aggravate the impact of other stresses (such as land-use and socio-economic changes) on water availability, freshwater ecosystems, energy production, navigation, freshwater supply and use (in agriculture, households, industry) and tourism. Adaptation actions will be needed such as improving water efficiency to mitigate water stress and enhancing retention to reduce flood risk.

5. Freshwater quality and biodiversity

Increased temperatures of lakes and rivers, by 1–3 °C during the 20th century, have resulted in decreases in ice cover on lakes and rivers by 12 days on average in the last century in Europe.

These changes can be attributed both to climate change, and to other causes such as freshwater use for cooling processes (e.g. power plants). Lake and river surface water temperatures are projected to increase with increasing air temperatures. Warming of surface water can have several effects on water quality and hence on human use and aquatic ecosystems.

6. Major European projects concerning climate change

The below list of projects and studies on climate change impacts are serving only as a samples related to the Tisza River Basin. It is an intention to develop a case study by 2012 for the Tisza River Basin where detailed analysis of projects results will be presented and discussed.

6.1. CLAVIER

The overall aim of the EU FP6 project CLAVIER (CLimate ChAnge and Variability: Impact on Central and Eastern EuRope) is to make a contribution to successfully cope with the challenges induces by climate changes. Three representative CEE Countries are studied in detail: Hungary, Romania, and Bulgaria.

In the framework of CLAVIER, ongoing and future climate changes are analyzed based on existing data and on climate projections with very high detail to fulfill the need of local and regional impact assessment.

The use of different conceptual hydrological models is foreseen to produce long term hydrological series. Upper-Tisza, **Mureş** /Maros catchments are foreseen comprising river systems in various climate and geo-morphological settings across the region. The simulations will be transient, covering the period 1960 – 2050. A validation for the Tisza Basin will be carried out based on the period 1984 – 2003 of observations. These partly physically based models will be used together with continuous stochastic simulation models to produce climate effect reports for a the selected basins with different types of hydrological regimes and flood problems including the interaction of basins of different runoff production significance and the coincidence and superposition of flood waves. (*VITUKI* and *INHGA*)

The results of the first climate change scenarios for the Tisza River Basin were reported by the end of 2009. Box 1 introduce samples of the outcomes of the climate change-related CLAVIER project.

Box 1. Results of the CLAVIER project

Results of the CLAVIER project

Transient model simulations were carried out from 1951-2050, and the validation was related to the period of 1984-2000. The sub-basin temperature and precipitation projections were analysed together with the investigation of the impact on the flow conditions.

Mean areal precipitation and temperature

Analysing the mean areal precipitation and temperature values, computed based on the A1B scenario (periods 1961-1990 and 2021-2050), for each of the sub-basins within the Tisza River Basin the following projections can be made:

- A general increase of the mean annual 2m air temperature for all of the sub-basins, with 1.4 ÷ 1.6 °C, with smaller changes for the spring period (0.8 ÷ 1.2 °C) and greater changes for the other seasons, especially winter (1.5 ÷ 2 °C);
- Great spatial variability in tendencies is foreseen for the annual precipitation with a slight increase up to 3.5% in Upper Tisza mountainous catchments and overall decrease in other sub-basins with 3 ÷ 10 %, while definite increase for winter periods (14 ÷17% in Upper Tisza), and general decrease in all other seasons with some exceptions in the highly elevated parts of the Upper Tisza.
- From the analysis of the mean areal precipitation and temperature values, computed based on the A1B scenario, for each of the sub-basins within the Mureş, the following potential climate change can be assumed:
    - A general increase of the mean annual 2m air temperature for all the basins, with 1.4 – 1.6 °C, with smaller changes for the spring period (1 – 1.2 °C) and greater changes (1.5 – 2 °C) for the other seasons
    - general decrease of the annual precipitation with -3 ÷ -5.5 %, but with an increase of 5.5 ÷ 8 % in Mureş Basin in winter, and general decrease in all the sub-basins for the other seasons, going up to – 15 ÷ -25 for some sub-basins in the spring and summer months mainly.

Results of the CLAVIER project (continue)

Hydrological results - *Changes in mean flow and seasonal distribution*

REMO5.7-ERA40 (1961 – 2000) and REMO5.7-A1B (1951 – 2050) data produced by the Max Planck Institute for Meteorology, Hamburg were used as climate change scenario. These climate change simulations were first pre-processed to fit the needs of the hydrological models[1]. The hydrological simulations were produced in 'natural flow' conditions, without taking into account the influence of the reservoirs. The hydrological model parameters reflect the present day land used – land cover influence on the basin's hydrological response. Model calibration was performed using observed historical data and regional parameters to some adjustments using the ERA40 data.

Based on the hydrological simulations, the analysis of the **mean seasonal and annual discharges** simulated time series show the following impact of the A1B climate change scenario:

For Tisza River and its tributaries the following are assumed:

- Slight increase in Upper Tisza and tributaries (less than 5%)
- No change or general decrease of the mean annual discharges, down to 15 % for Central Tisza and southern basins
- The mean seasonal discharges are increasing only in winter season, in all the basins but with significant variations (3 ÷ 42 %);
- For the spring-autumn period, the hydrological simulations indicate a decrease of the mean discharges for most of the catchments in southern basins between -15 ÷ -20 %
- To estimate the A1B climate change scenario impact on the hydrological regime the variations of the **mean monthly simulated discharges** for selected 30-year periods (1961 – 1990 as reference period and 2001 – 2030, 2011 – 2040, 2021 – 2050 as representative periods for the future) were also analysed.
- The preliminary results in most cases indicate a slight decrease of annual mean flow throughout the region, with significant spatial variability and even some increase for the high elevation zones in the Upper Tisza sub-catchments. The decrease of spring runoff is compensated for by the flow resulting from thaw during late winter.

Floods - No clear picture can be drawn about possible changes in the flood conditions. While more frequent winter floods are expected, the decrease of mean flow in some seasons is not followed by the decrease of flood peaks. Torrential type of flood events may occur even more frequently, while the frequency of floods with long duration and large volume may become lower.

Reference: http://www.clavier-eu.org/

6.2.CECILIA

The project CECILIA (Central and Eastern Europe Climate Change Impact and Vulnerability Assessment) is part of EU FP6. CECILIA's primary mission is to improve the understanding of local climate change in Central and Eastern Europe and its impacts into forestry, agriculture, hydrology and air quality.

The main objective of CECILIA is to deliver a climate change impacts and vulnerability assessment in targeted areas of Central and Eastern Europe. Emphasis is given to applications of regional climate modeling studies at a resolution of 10 km for local impact studies in key sectors of the region. The project contains studies of hydrology, water quality, and water management, air quality issues in urban areas agriculture (crop yield, pests and diseases, carbon cycle), and forestry (management, carbon cycle).

Very high resolution simulations over this region are necessary due to the presence of complex topographical and land use features. Climate change impacts on large urban and industrial areas modulated by topographical and land-use effects which can be resolved at the 10 km scale are investigated by CECILIA. The high spatial and temporal resolution of dense national observational networks at high temporal resolution and of the CECILIA regional model experiments will uniquely feed into investigations of climate change consequences for weather extremes in the region under study. Comparison with the results based on statistical downscaling techniques will also be provided. Statistical downscaling methods for verification of the regional model results will be developed and applied, and assessments of their use in localization of model output for impact studies will be performed.

6.3.ADAM

Funded by the European Commission and coordinated by the UK Tyndall Centre for Climate Change Research, ADAM (Adaptation and Mitigation Strategies: supporting European climate policy) is an integrated research project running from 2006 to 2009 that will lead to a better understanding of the trade-offs and conflicts that exist between adaptation and mitigation policies. ADAM will support EU policy development in the next stage of the development of the Kyoto Protocol and will inform the emergence of new adaptation strategies for Europe.

ADAM will examine the extent to which existing policy trajectories in Europe will deliver Europe's commitments to these agreements and will co-develop with stakeholder’s portfolios of policy options where current trajectories are insufficient.

The objectives of the project are:

- to assess the extent to which existing climate policies can achieve a socially and economically tolerable transition to a world with a global climate no warmer than 2^0C above pre-industrial levels.
- to develop a portfolio of longer term policy options that could contribute to the EU 2^0C target, and targets for adaptation.
- to develop the requirements for climate change appraisal in different contexts to enhance the emergence of innovative mitigation and adaptation strategies.

For the aims of ADAM water management in the Hungarian Tisza region offers an attractive case to study mainstreaming adaptation and mitigation. Climate change is connected to the three main water-related problems of the Tisza region: floods, in-land water stagnation and droughts.

The ADAM project is studying what happened in Hungary in the period leading up to the breakthrough year of 2003 and in the following years when actors had to deliver on the new direction taken in water management. It is examining under what conditions floodplain revitalization, land use change and rural development reduce climate-related risks in the Hungarian Tisza River Basin. The project assesses the agricultural and hydrological consequences of climate change, as well as the institutional setting conducive to climate change adaptation and mitigation.

6.4. Study on 'The Changing Annual Distribution of Rainfall in the Drainage Area of the River Tisza during the Second Half of the 21st Century'.

Box 2 introduce the outcomes of a study on '*The Changing Annual Distribution of Rainfall in the Drainage Area of the River Tisza during the Second Half of the 21st Century*'[2].

Box 2. Changing annual distribution of rainfall in the drainage area of the Tisza River

Changing annual distribution of rainfall in the drainage area of the Tisza River

'In this study[60] only one possible climate change scenario has been investigated, which can be seen as a plausible indication for future developments. However it is important to analyse the uncertainty in follow-up studies taking into account regional climate change simulations from various models.

Compared to the control period, the mean monthly temperatures will increase in the period 2061–2090, which will influence the hydrological circle.

The annual rainfall will decrease in the future. The decrease of rainfall is expected in the mountainous regions.

In winter and at the beginning of spring, both high water level and a danger of inland waters (Pálfai 2000) can result from the increasing winter drainage – in the form of rainfall – in the drainage area of the Upper Tisza, Szamos, Körösök and the Bodrog. If the rainfall arrives on a frozen surface, the soil can not delay the duration of the runoff, therefore the collection period of the water is reduced. The first maximum discharge of the Tisza is postponed as a result of the decreasing amount of snow (Radvánszky & Jacob 2008).

The rise of the amount of mean rainfall in March and April can result in high water level on the main rivers in the last two spring months. As a consequence of the significant discharge, the high water level affects the water level of the influent streams as well. When the Danube has a flood wave at the same time the Tisza can lose its hydrological independency. In this case one has to be prepared to face long-lasting flood prevention.

The absolute amount of the first maximum rainfall will decrease at the beginning of summer. Therefore frequent green flood with lower discharge is to be expected. The model forecasts a fall of the mean rainfall during the summer months, thus the possible occurrence of long droughts will increase. A lesser amount of drainage in the mountainous regions results in a moderate surface runoff, and the rivers will have a permanently low water level.

Because serious droughts are most significant in the Great Hungarian Plain (Gálos et al. 2007), agriculture, public health, as well as water management will face further challenges. Due to the more vivid Mediterranean cyclones in October and November, the amount of the second maximum rainfall will increase in the south-western parts of the drainage area. The results inevitably testify to the fact that the influence of these Mediterranean cyclones will be more noteworthy in the annual distribution of rainfall in the drainage area of the Tisza, and the characteristic features of the Mediterranean climate are going to become more dominant'. [60]

Reference: B. Radvanszky, D. Jacob, 2008

[2] Radvanszky B, Jacob D, 2009